Brief communication: dentists' reproducibility in scoring the plaque index using a fluorescent colouring agent

Précis

The levels of agreement of the Silness-Löe plaque index measurements using Plaque Test (a fluorescent colouring agent) were fair to good among eight dentists.

Abstract

Statement of the problem: Fluorescein is a plaque detection agent, which fluoresces yellow-green when excited with blue light (dental light curing lamp). Little is known about the reproducibility of scoring with the Silness-Löe plaque index (1964) when using this agent.

Purpose of the study: To evaluate the level of agreement of the plaque index measurements using a fluorescent colouring agent among eight dentists.

Materials and methods: Eight dentists in Cork were recruited as examiners for a randomised clinical study investigating the impact of a personalised caries prevention approach. They were trained and calibrated in the use of the plaque index using Plaque Test (Ivoclar Vivadent, Liechtenstein) in the Oral Health Services Research Centre and School of Dental Hygiene, University College Cork. For inter-examiner and intra-examiner reproducibility, a previously calibrated 'gold standard' examiner and seven dentists examined 10 to 12 subjects each, while one dentist examined four subjects only for inter-examiner reproducibility. The adult subjects were recruited at the Cork University Dental School and Hospital. To evaluate inter-examiner and intra-examiner reproducibility at site level, squared weighted kappa statistics were calculated.

Results: The weighted kappa statistics varied from 0.31 to 0.54 for inter-examiner reproducibility under the acceptable level (kappa statistics = 0.60) for research purposes and from 0.43 to 0.65 for intra-examiner reproducibility.

Conclusions: The levels of agreement were fair to good. Further studies are needed, preferably including a qualitative study to analyse feedback from dentists to determine the cause of such variation. This study re-emphasises the importance of clinician calibration ahead of clinical studies.

Keywords: Dental plaque index; fluorescent dyes; reproducibility of results; calibration; risk assessment.

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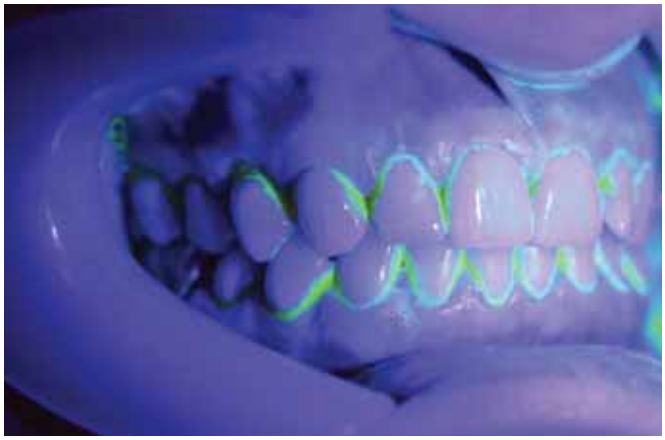

FIGURE 1: Colour change of Plaque Test with and without blue light.

Introduction

Dental plaque (biofilm) is the community of microorganisms on a tooth surface, consisting of a variety of acidogenic, non-acidogenic, and base-producing organisms.[1] Therefore, plaque level is an important factor for the assessment of an individual's risk of caries and periodontal diseases.[2,3] Visualising dental plaque with a disclosing agent is effective not only for risk assessment, but also for patient education.[4]

There are various formulations of disclosing agents. One of them is fluorescein that fluoresces yellow-green when excited with blue light (dental light curing lamp) (**Figure 1**). Since fluorescein is invisible in daylight,[5] this plaque detection agent is aesthetically preferable to patients. It stains most plaque components, with the possible exception of the pellicle.[6] Fluorescein as a plaque-disclosing agent was introduced by Brilliant in 1967 (US Patent 3-309-274; 1967). When fluorescein came to market, it was considered to have fulfilled the ideal characteristics of a plaque-disclosing agent.[7]

Given the anticipated benefits of using a disclosing dye on patients that would not be visible following plaque assessment, we decided to evaluate fluorescein as a suitable disclosing agent with the Silness-Löe plaque index (1964),[8] which we planned to use for a randomised controlled clinical study investigating caries risk assessment. Little is known about the reproducibility of the plaque index when using this disclosing agent. The aim of the present study was to evaluate the level of agreement of Silness-Löe plaque index measurements using a fluorescein (Plaque Test – Ivoclar Vivadent; Liechtenstein) among eight dentists.

Materials and methods

Eight dentists (volunteers) in Cork were recruited as examiners for a clinical study investigating caries risk parameters with the cariogram.[9] This required the dentists to be proficient in the use of the Silness-Löe plaque index (1964).[8] The methodology described here covers: (1) the calibration training (lecture plus clinical session); and, (2) the calibration assessment of these eight dentists in the use of the plaque index using Plaque Test (**Figure 1**). All subjects for both: (1) the calibration training; and, (2) the calibration assessment provided informed consent prior to being examined. The Clinical Research Ethics Committee of the Cork Teaching Hospitals approved the calibration exercise. The Dental Council of Ireland approved the tuition, training and calibration of the trainee-examiner dentists as part of its continued professional development (CPD) programme.

The conference room at the Oral Health Services Research Centre (OHSRC) and dental units in the adjacent School of Dental Hygiene were used. A front surface mirror size 4 head or equivalent, a visible light curing unit, disposable applicator brushes and a dappen glass were prepared. The eight dentists and the gold standard examiner (Professor of Restorative Dentistry (Periodontology) in University College Cork) were supplied with a bottle (11g) of Plaque Test. Protective glasses were placed on each subject before the oral examination commenced. As each subject was examined by multiple dentists, in order to avoid disturbing the dental plaque, only visual inspection was recommended and the use of the community periodontal index (CPI) probe avoided. Before each clinical examination, Plaque Test was applied according to the manufacturer's instructions on the four surfaces of six reference teeth (upper right first molar, upper right lateral incisor, upper left first premolar, lower left first molar, lower left lateral incisor and lower right first premolar). Each dentist reapplied Plaque Test throughout the study using a disposable applicator brush. Each of the four surfaces of the six reference teeth was scored 0-3 to record both soft debris and mineralised deposits (**Table 1**). Missing teeth were not substituted.

1) The calibration training (lecture with clinical session)

As theoretical background, the gold standard examiner (AR; previously calibrated for industry clinical trials) gave the eight trainee-examiner

Table 1: Description of scores used by the Silness-Löe Plaque Index.[8]

Score	Description
0	No plaque
1[a]	A film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may be seen in situ only after application of disclosing solution on the tooth surface.
2	Moderate accumulation of soft deposits within the gingival pocket or on the tooth and gingival margin which can be seen with the naked eye.
3	Abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin.

[a]*Score 1 was modified for the current study.*

dentists a 40-minute interactive presentation/discussion, during which clinical photographs of patients who had been disclosed with Plaque Test were used to discuss the scoring system for the Silness-Löe plaque index. Immediately following this theory training, the gold standard examiner and the eight dentists had a clinical training session with eight patient subjects. During this hour-long practical training, the gold standard examiner discussed the recorded scores in detail with the trainee examiners until they could confidently categorise the level of dental plaque present.

2) Determining both inter- and intra-examiner reproducibility

To permit determination of the kappa statistics for both inter- and intra-examiner reproducibility of plaque assessment, the eight trainee-examiner dentists returned to the clinic to examine a second convenience sample of 12 patients one week after training. The gold standard examiner examined all 12 subjects, seven trainee examiners each examined 10-11 of the 12 subjects, while one trainee examiner had to leave early due to personal reasons and only examined four subjects. Each of the seven trainee examiners re-examined their 10-11 subjects approximately 1.5 hours after their first examination. The subjects were aged between 19 and 75 years (mean age: 40.9±23.9 years, median age: 25) and were recruited through the restorative clinic at Cork University Dental School and Hospital.

For this calibration assessment session, the sample size for required tooth surfaces was calculated for the Cohen's kappa statistic (un-weighted) with a null hypothesis value (an unacceptably low level of agreement) as 0.60[10] and an alternative hypothesis value (a clinically acceptable level of agreement) as 0.75 which was derived from recent available literature.[11,12] The marginal probabilities given by examiners were estimated from the results of the training session as 0.10, 0.40, 0.30, and 0.20 for scores 0, 1, 2 and 3, respectively. Given these data with a significance level of 5% (two-sided) and a power for that detection of 80%, we estimated that 147 tooth surfaces (seven subjects) would be needed per examiner. Therefore, also considering that some patients may be missing a reference tooth or teeth, we recruited ten subjects to have well over the 147 surfaces needed. It should be noted that there was an inherent assumption that the 147 surfaces are independent, although some of the given surfaces were from the same teeth within the same patient. We calculated how many times each subject was examined for inter- and intra-reproducibility and gold standard measurement, and squared weighted kappa statistics for all sites examined to evaluate inter-examiner and intra-examiner reproducibility at site level using a statistical programme, R.[13] We did not calculate kappa statistics for the calibration training session.

Results

On average, each subject was examined 13.1±4.7 times during the calibration assessment session. The maximum value was 16 times. For inter-examiner reproducibility, one dentist examined 11 subjects, six dentists examined ten subjects each, and one dentist examined four subjects (**Table 2**). The number of examined tooth surfaces per trainee examiner was 184 for five dentists, and 208, 160 and 60 for the other three dentists. The kappa results for inter-examiner reproducibility were moderate for five dentists (0.42 to 0.54), and fair for the other three dentists (0.31 to 0.40).

For intra-examiner reproducibility, seven dentists examined ten subjects and six dentists examined one subject (**Table 2**). One dentist did not examine any subject for intra-examiner reproducibility. Numbers of examined tooth surfaces were 184 for six dentists, 160 for one dentist, and zero for one dentist. The results of the kappa value for intra-examiner reproducibility were that two dentists were barely good (0.64, 0.65) and the other five dentists were moderate (0.43 to 0.56).

Table 2: Numbers of patients/tooth surfaces and inter- and intra-reproducibility by trainee-examiner dentist

Trainee-examiner dentist ID	Number of patients inter/intra*	Number of tooth surfaces inter/intra*	Inter-reproducibility	Intra-reproducibility
1	4/0	60/0	0.54	-
2	10	184	0.42	0.53
3	10	184	0.40	0.64
4	11/10	208/184	0.47	0.55
5	10	184	0.42	0.65
6	10	184	0.43	0.56
7	10	184	0.31	0.43
8	10	160	0.32	0.45

** When the numbers are different between inter-examiner and intra-examiner, both numbers are presented.*

Usually, 0.60 is considered acceptable for research purposes.[10] Thus, we have decided that the kappa results were poor enough to reject using Plaque Test in the planned randomised controlled clinical study by the eight dentists.

Discussion

The current study presented fair to moderate inter-examiner reproducibility and moderate to good intra-examiner reproducibility using Plaque Test among eight dentists. All of the participating dentists were experienced dental practitioners, with three dentists also working as clinical instructors at the Cork University Dental School and Hospital, and one dentist often participating in clinical trials with the OHSRC. However, none of the trainee examiners reached good reproducibility (0.61 to 0.80); if the reproducibility value is below 0.60, little confidence should be placed in the study results.[10] We discuss possible reasons for the poor reproducibility considering two aspects: the Silness-Löe plaque index and the Plaque Test.

The Silness-Löe plaque index has been widely used and is respected.[14] However, if the plaque deposits are disturbed during data collection, it is difficult to conduct repeat evaluations with multiple examiners.[14] Therefore, the trainee examiners and the gold standard could not collect dental plaque from the subjects by running a probe over their tooth surfaces; furthermore, the plaque index measures the thickness of gingival plaque with no consideration of the coronal extension of the plaque.[14] Nonetheless, the reproducibility of the plaque index in the current study was lower than in previous studies using the same plaque index. For example, Paschoal *et al.*[11] reported that their intra- and inter-kappa index values were 0.75; Markeviciute and Narbutaite[15] reported that their inter-examiner reproducibility was 0.76; Zini *et al.*[16] reported that all kappa index values were above a level of 0.87 for intra-examiner agreement. It is unknown whether these studies used a disclosing agent or not.

In relation to using Plaque Test as a disclosing agent product, to the best of our knowledge, there has been no published literature reporting low

reproducibility for plaque assessment. In the current study, however, multiple examiners reported that Plaque Test did not stay on tooth surfaces and that it was difficult to detect plaque consistently, though caution is necessary in considering this reason as examiner feedback was collected spontaneously and not in a manner appropriate to a qualitative study. Clinicians should note its viscosity in use; Zingler *et al.*,[17] who used Plaque Test in their study, described that it will be necessary to insert cheek retractors and cotton rolls between the upper and lower teeth, and the teeth should be carefully air-dried. In addition, Plaque Test needs a fluorescent curing light, which is an additional variable and a possible influencing factor. The gold standard noticed that the tip of the curing light only had to be in the vague vicinity of the surface being examined, since having the tip further away was better. Although the dentists were informed of this, we did not set a definite distance and did not calibrate our curing lights.

We applied squared weighted kappa statistics for the current study. For the plaque index, being one scale unit off from perfect agreement is not as serious an error as being two units away from agreement, and weighted kappas are better statistics for examining reproducibility than the unweighted kappas.[18] Spolsky and Gornbein mention that since squared weights give a slightly higher value to the near misses than linear weights, squared weights are preferable and more consistent with the clinical rationale. Thus, we applied the higher squared weighted kappa values rather than using unweighted kappa and linear weights. As it is unknown which type of kappa statistics were used for previous studies on the Silness-Löe plaque index, it could be that the reproducibility of the plaque index in the current study might be even lower than in previous studies.

Fluorescein – Plaque Test was chosen as fluorescent colouring agents have an advantage for patients, given that they do not stain hard and soft tissues. Fluorescein has been regarded as fulfilling the ideal characteristics of a plaque-disclosing agent, such as: (1) to stain specifically bacterial plaque; (2) to contrast with the gingiva; (3) to be non-pathogenic and non-antibacterial; and, (4) to be convenient and pleasant to use and aesthetically acceptable to the patient.[7] Although a visible light curing unit is necessary for their use, nowadays every dental practice is equipped with such units for resin polymerisation. It would thus be easy for dental practices to introduce the use of fluorescent colouring agents.

Due to the calibration results, we chose not to use any disclosing agent in the randomised controlled clinical study but to apply a clinical estimation of plaque amount by visual overall inspection according to the cariogram manual.[19] This method is based on a scale from score 0 to score 3, using a description similar to the Silness-Löe plaque index. Nevertheless, if air flow is commonly equipped, a visible dye may be a better alternative. Chetrus and Ion showed that air flow with sodium bicarbonate powder removed 100% of plaque dyed with fuchsin colouration, while professional cleaning removed 86%.[20] Another possible option is visualising mature dental plaque (more pathogenic)[21] with the Quantitative Light-induced Fluorescence (QLF) device. The phenomenon of red fluorescence emitted by dental plaque itself after excitation with blue light at 405nm from a QLF device has been studied intensively.[14,22-25] The red fluorescent plaque (RFP) is probably associated with the metabolic products of the mature dental plaque.[25] However, the correlation between RFP and disclosed plaque is not strong.[14,22]

Limitations of the current study are that the study design was originally developed in preparation for a randomised controlled clinical study, that the number of dentists was small and that they were a convenience sample. Therefore, the generality of our finding is limited and a definitive conclusion can be drawn only with extreme caution. Further studies are needed to confirm the reproducibility of plaque index using Plaque Test, preferably including a qualitative study to analyse feedback from dentists. To introduce research findings to patient benefit, it is desirable to conduct practice-based research, and have general dental practitioners trained to collect the data. This involves training and calibration, and there is an ongoing need to ensure robust evaluation of the data collected in a practice-based setting.

Conclusions

The agreements for plaque index using Plaque Test were under the acceptable level (kappa statistics = 0.60) for research purposes, with the exception of two dentists for intra-reproducibility. Further studies are needed, preferably including a qualitative study to analyse feedback from dentists to determine the cause of such variation. This study re-emphasises the importance of clinician calibration ahead of clinical studies.

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